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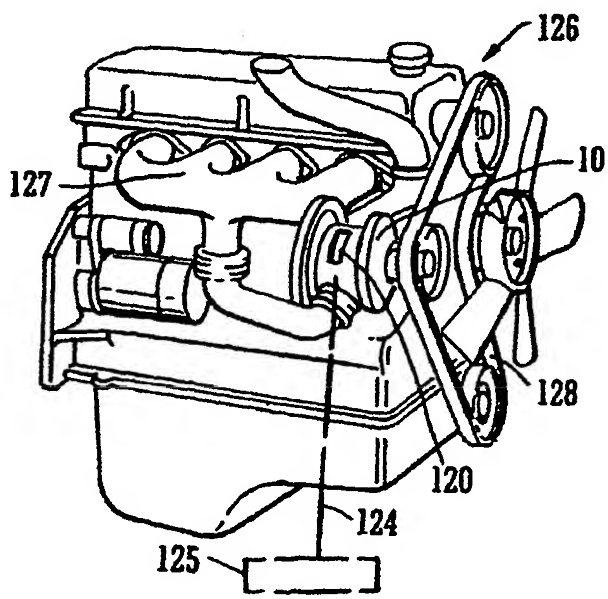
(54) Title: A ROTARY POSITIVE-DISPLACEMENT FLUID MACHINE



(57) Abstract: A rotary positive-displacement fluid machine (10) adapted, for example, to be connected to an internal combustion engine (126) and to be driven by the pressure difference between the ambient air and that at the engine inlet manifold, and connected to the engine crankshaft to provide mechanical advantage thereto in certain operating conditions of the engine, an air inlet port (120) to the machine being throttled by a sliding plate (101) mounted on the machine casing (11) in bearings, and a further sliding plate (103) movable to permit controlled leakage of air within the machine thus to prevent icing and to provide a pressure boost for supercharging.

WO 01/20167 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A ROTARY POSITIVE-DISPLACEMENT FLUID MACHINE

THIS INVENTION concerns rotary positive-displacement fluid machines. Such a machine is described in specification WO 98/57039 and comprises a rotor eccentrically mounted in a casing for rotation about an axis, the rotor having recesses respectively receiving vanes extending parallel to the axis between a pair of axially spaced side discs. The vanes oscillate in the recesses as the rotor rotates. Each vane has a vane tip which maintains a clearance fit within the casing, and is connected by a crank to an arm for oscillation about a vane axis which is located inwards of the outer extremity of the vane The tip of each vane is preferably curved about the vane axis. The rotor is mounted on a shaft which may be connected to the crank shaft of an internal combustion engine and driven by the pressure difference between the ambient air and that at the engine inlet manifold. Alternatively, the device may operate as a heat pump.

In specification WO 98/57039 there is described a variable air inlet port having a slider to vary the extent of the port according to the operating conditions of the engine. The port is enlarged automatically and gradually as the engine power increases. Preferably, the slider is connected to the engine throttle or accelerator pedal and is moved automatically according to the extent of opening of the throttle.

The slider creates a variable port and is part of the casing.

It has also been proposed in patent specification WO 99/30005 to provide several sliders providing smooth progression between conditions in which the machine provides for throttle loss recovery at low speed, and supercharging at higher speeds.

According to the present invention there is provided a rotor eccentrically mounted in a casing for rotation about an axis, the rotor having recesses respectively receiving vanes which oscillate in the recesses as the rotor rotates, each vane being adapted for oscillation about a vane axis such that the vanes divide the interior of the casing into separate chambers of cyclically varying volume as the rotor rotates; sliding throttle means being movably mounted on the casing to permit variation of fluid flow into and from the chambers as the rotor rotates; characterised in that the sliding throttle means comprises the first slider movable to permit controlled fluid flow directly and sequentially into and from the chambers, and further means movable to permit controlled leakage of fluid between an adjacent pair of chambers to allow the fluid to expand within the chambers without applying substantial motive force to the rotor, thus to prevent an excessive drop in fluid temperature.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a perspective view part cut away of a rotary positive-displacement fluid machine to which the invention applies;

Fig. 2 is a schematic cross-section of a part of the machine;

Fig. 3 is a schematic end view of the machine;

Fig. 4 shows an engine;

Fig. 5 is an enlarged cross-section through the wall of the machine;

Fig. 6 is a diagrammatic view taken in the direction of arrow A in Fig. 5, with sliders located in a position for naturally aspirated throttle loss recovery;

Fig. 7 is a cross section on line B-B in Fig. 6;

Fig. 8 is view similar to Fig. 6, showing the sliders in a position for natural aspiration but with no throttle loss recovery;

Fig. 9 is a cross section on line C-C in Fig. 8;

Fig. 10 is a view similar to Figs. 6 and 8 showing the sliders in a position for supercharging;

Fig. 11 is a cross section on line D-D in Fig. 10;

Figs. 12A and 12B show a mechanism for permitting smooth operation of the sliders;

Fig. 13 shows a preferred construction of a slider:

Fig. 14 is a cross section on line E-E of Fig. 13:

Figs. 15A to 15C show the underside of a slider. according to three embodiments;

Fig. 16 is a view similar to Fig. 3 including a pressure balanced seal;

and Fig 17 shows a drive mechanism for a slider.

Referring now to the drawings a rotary positive-displacement fluid machine 10 has an outer casing assembly 11 within which can rotate an eccentrically mounted rotor assembly 12. The casing assembly 11 has a first end plate 13, a two-part radially stepped casing part 14, 15 and a second end plate 16, the assembly being held together by bolts 17, with fluid-tight seals as appropriate (not shown), and providing an expansion/compression chamber 70 (Fig. 3).

The rotor assembly 12 comprises a rotor 20 with angularly spaced peripheral recesses 33 receiving respective vanes 21. Each vane 21 is attached to or

integral with end shaft 23 mounted respectively for rotation (oscillation) about axis 32 on bearings 24a, 25a in axially spaced rotor side discs 24 and 25 secured to the rotor 20 by bolts 26 (only one shown). The shafts 23 are pivotally connected by respective integral crank arms 27 to oscillating arms or spokes 28 which can oscillate about a common axis on a shaft 29 which is fixed in the second end plate 16.

The arms 28 rotate with the rotor and also oscillate on the shaft 29. The arms 27 oscillate about axes 35 (Fig. 3).

A drive shaft 40 with an axis 41 offset from the axis 30 is attached to the rotor assembly.

Referring to Fig. 3, with this arrangement, the vanes 21 oscillate about their pivotal axes 32 in the recesses 33 to produce a compression region 43 and an expansion region 44 with the outer tip surface 45 of each vane 21 disposed with very small running clearance with respect to the inner surface 46 of the casing 14. During rotation of the rotor, each vane 21 also oscillates about a vane axis 35 spaced inwardly from the vane tip 45.

Referring now to Fig. 5 a section of the machine is shown with vanes 21 having outer tips 45 close to the wall of the casing 14 and arranged to pivot as described in relation to Fig. 1. In Fig. 5 the distance shown as BVT represents that existing between consecutive vane tips and as will be seen from Figs. 4 and 6 the wall of the casing includes

an inlet port 120 the extent of opening of which around the periphery of the casing is determined by the positioning of a first sliding plate 101 which allows air to pass into the chambers between the vane tips as the rotor rotates. The effective outer diameter of the rotor is shown at 102, and a second sliding plate 103 is located alongside the plate 101 but does not provide direct access to the exterior of the machine.

Fig. 6 shows a typical normal operating position for the machine when operating under throttle loss recovery with plate 103 occupying the zone between positions M and N while the plate 101 may be moved to adjust the open extent of the air inlet port 120. In this condition, the incoming air may move across the machine to occupy the entire width of the chamber defined by the side discs 24 and 25, and between an adjacent pair of vanes, as indicated by arrow 1A in Fig. 7. The space labelled BVT is always occupied by a part of both sliders 101 and 103.

In a machine of this kind, when the throttle loss turbine (the rotor) expands the intake air, the expanded air temperature is reduced, perhaps by more than 20°C which can cause icing so that the moving parts of the mechanism can become jammed.

Under a condition of naturally aspirated, no-throttle loss recovery, as shown in Figs. 8 and 9, the slider 103 has been moved to a position wherein the incoming

air is free to flow as shown by arrow 1B, through a space X vacated by the slider 103, and since air may thus pass through the slot vacated by the slider 103 there is controlled leakage of the air past the adjacent vane tip whereby the air can expand fully without applying motive force to the rotor. Since no work is being done by the turbine or rotor, there is therefore no temperature drop and so icing is prevented and the sliding throttle plate 101 acts only as a throttle in the same way as a conventional butterfly valve.

When the engine has been run up to operating temperature and the risk of icing is no longer present, the slide 103 is returned to position M.

Referring now to Figs. 10 and 11, under supercharging conditions, once the throttle plate 101 has reached full throttle position (at F) the slider plate 103 is moved back in the direction of arrow G to boost the manifold pressure. The further the slider 103 moves, the greater is the pressure, from zero to maximum boost.

Referring now to Fig. 12A and 12B, it will be seen that the slider may be mounted on three pairs of bearings 200 for ease of movement, the rollers being just proud of the surface.

The efficiency of a machine of this kind depends, to a large extent, upon the clearance between each vane tip and the adjacent wall of the casing which in the vicinity of the inlet port is the inner surface of the slider. To achieve a close clearance requires several components to have very small manufacturing tolerances. Referring to

Figs. 13 and 14 there is provided a flexible surface slider including a strip of plain bearing material 205 containing a vent hole 206 and being attached by a flexible and compressible band 207 to an inner surface of the slider, leaving a pocket 208 between the slider and the bearing material 205.

Thus, to avoid supercharger pressure over-compressing the flexible material band 207, several pockets 208 are machined in the body of each slider and the pressure in equalised between the pockets in view of the existence of the vent holes 206.

Referring now to Figs. 15A to 15C where the underside of a slider is shown according to three embodiments, the number of pockets 208 in a slider is determined by the amount the pressure is allowed to compress the flexible band 207. In Fig. 15B, the serrated edge 209 will serve to attenuate pressure fluctuations during transient operating conditions. During a transient condition the pressure inside the machine will be different from that in the engine manifold and so noise would be generated when the air suddenly expands. The serrated edge enables a gradual increase or reduction of the pressure. In Fig. 15C an inclined or angular forward edge 210 provides a similar gradual effect.

Referring now to Fig. 16, which is similar to Fig. 3 there may be provided a pressure balanced seal 300 spring-loaded against the outer surface of the vanes as they progress around the machine. The seal is contained within a chamber 301 which is in communication with a further chamber 302 which itself communicates with the

interior of the machine. Only a light spring-loading of the seal against the outer surface is required since the pressures on opposite sides respectively of the seal are balanced.

Referring now to Fig. 17. there is shown a drive system for the respective sliders which may comprise a centrally toothed flexible belt 400 which wraps a centrally toothed motor driven timing gear 401. The respective ends of the belt 400 are fixed to the respective end regions of the slider at 402 and 403 so that operation of the timing gear drives the belt in opposite directions as illustrated by arrow 404 selectively to advance the associated slider. Pressurised idler pulleys 405. 406 may be provided to ensure adequate traction, and spring-loaded slider seals 407, 408 may be provided to the sides of the idler pulleys respectively. The idler pulleys may be replaced by fixed casing parts around which the belt slides.

Operation of the sliders 101, 103 may be computer controlled by connection as at 124 (Fig. 4). An engine management system thus to afford optimum running and maximum advantage from the machine which in this example is connected to the engine 126 to be driven by the pressure difference between ambient air at inlet port 120 and that at the engine inlet manifold 127, the driven shaft 40 of the machine being drivingly connected (by belt 128) to the engine crankshaft. The slider 101 serves to vary the effective size of port 120.

CLAIMS

1. A rotary positive-displacement fluid machine comprising a rotor eccentrically mounted in a casing for rotation about an axis, the rotor having recesses respectively receiving vanes which oscillate in the recesses as the rotor rotates, each vane being adapted for oscillation about a vane axis such that the vanes divide the interior of the casing into separate chambers of cyclically varying volume as the rotor rotates; sliding throttle means being movably mounted on the casing to permit variation of fluid flow into and from the chambers as the rotor rotates; characterised in that the sliding throttle means comprises the first slider movable to permit controlled fluid flow directly and sequentially into and from the chambers, and further means movable to permit controlled leakage of fluid between an adjacent pair of chambers to allow the fluid to expand within the chambers without applying substantial motive force to the rotor, thus to prevent an excessive drop in fluid temperature.

2. A rotary positive-displacement fluid machine according to Claim 1, wherein the further means comprises a second slider mounted alongside the first slider and movable independently of the first slider.

3. A rotary positive-displacement fluid machine according to Claim 1 or Claim 2, wherein the further means is movable selectively to a position in which leakage of fluid between an adjacent pair of chambers is prevented.

4. A rotary positive-displacement fluid machine according to Claim 2, wherein the first and second sliders are mounted on the casing to have surfaces which lie flush with the inner casing wall thus to define a running clearance with a tip surface of each vane during rotation of the rotor.

5. A rotary positive-displacement fluid machine according to Claim 2, wherein the first and second sliders overlap circumferentially by an amount equivalent to the maximum space between the tips of adjacent vanes.

6. A rotary positive-displacement fluid machine according to any preceding claim, wherein the or each slider is mounted on the casing in bearings for ease of movement.

7. A rotary positive-displacement fluid machine according to any preceding claim, wherein the or each slider includes a strip of plain bearing material disposed to provide a close running clearance with the tips of the vanes as the rotor rotates, the bearing material being mounted compressibly on its respective slider to define a pocket between the body of the slider and the bearing material.

8. A rotary positive-displacement fluid machine according to Claim 7, wherein the bearing material strip includes a vent hole to permit passage of air to and from the pocket.

9. A rotary positive-displacement fluid machine according to Claim 7 or Claim 8, wherein the or each slider comprises several discrete pockets between which air may pass through a plurality of vent holes in the bearing material.

10. A rotary positive-displacement fluid machine according to any preceding claim, wherein at least one end of the or each slider includes a graduated edge formation to attenuate pressure fluctuations during transient operating conditions.

11. A rotary positive-displacement fluid machine according to Claim 10, wherein said edge formation is a serrated edge.

12. A rotary positive-displacement fluid machine according to Claim 10, wherein said edge formation is an inclined or angular forward edge.

13. A rotary positive-displacement fluid machine according to any preceding claim, in conjunction with an internal combustion engine and connected thereto to be driven by the pressure difference between the ambient air and that of the engine inlet manifold, the rotor including a shaft drivingly connected to the crankshaft of the engine.

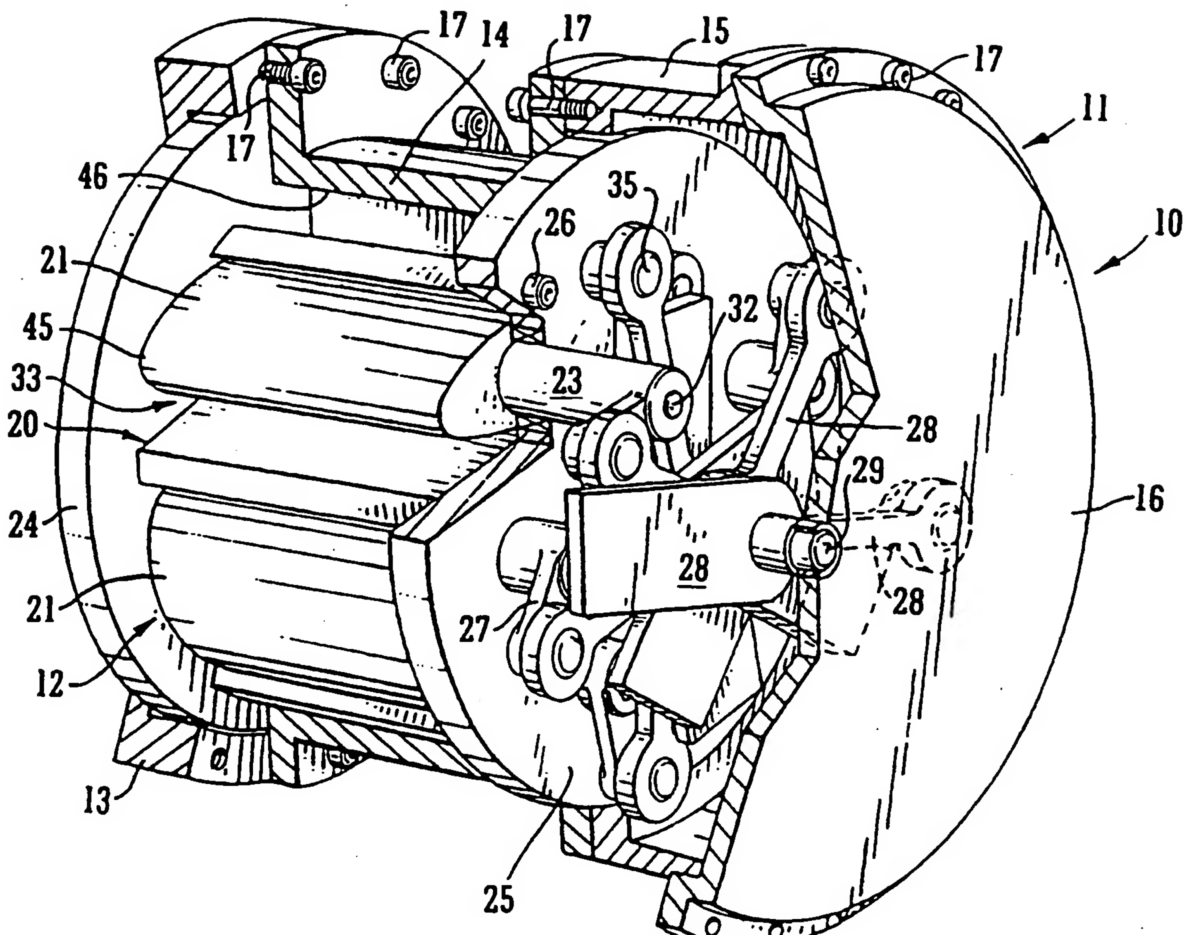


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FIG. 1

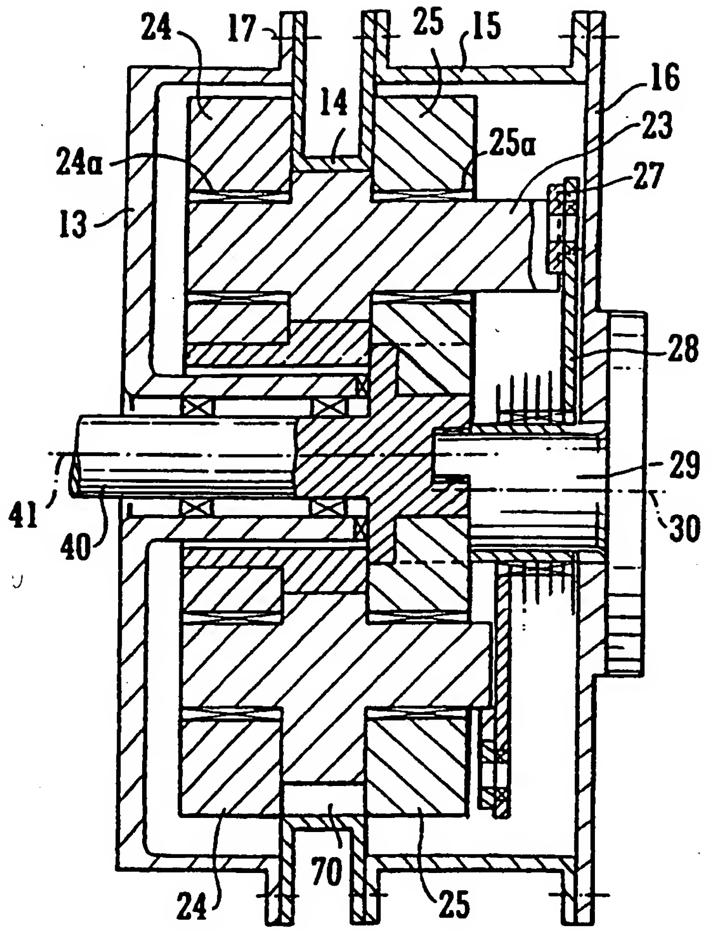

FIG. 2

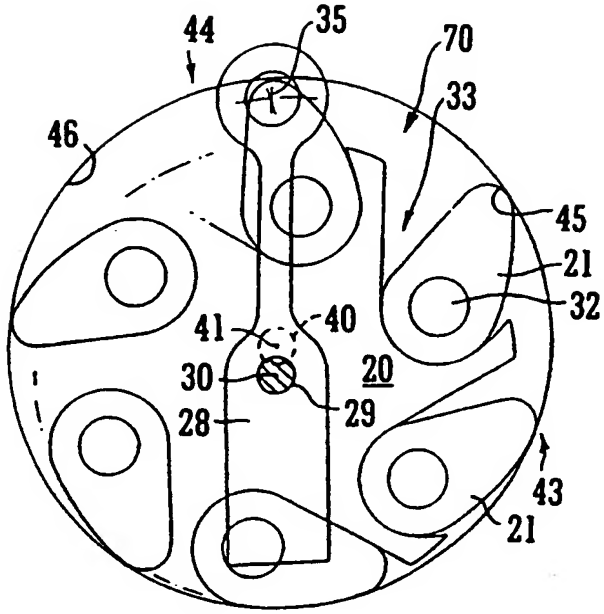
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FIG. 3

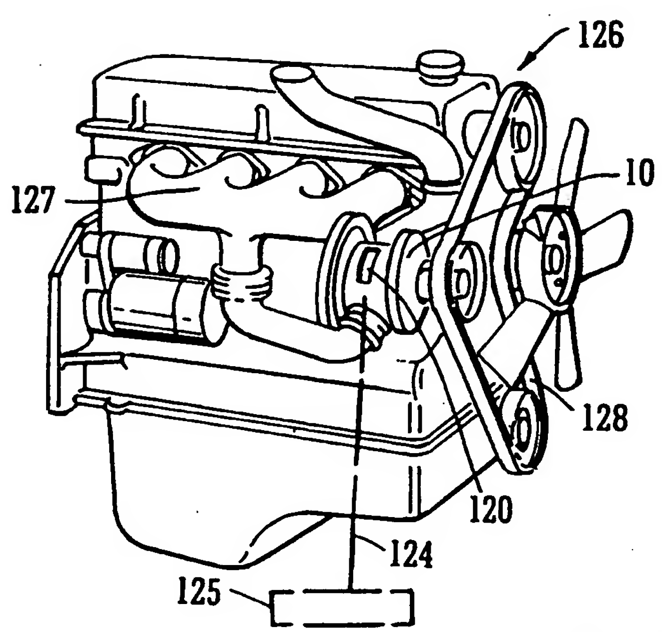
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FIG. 4

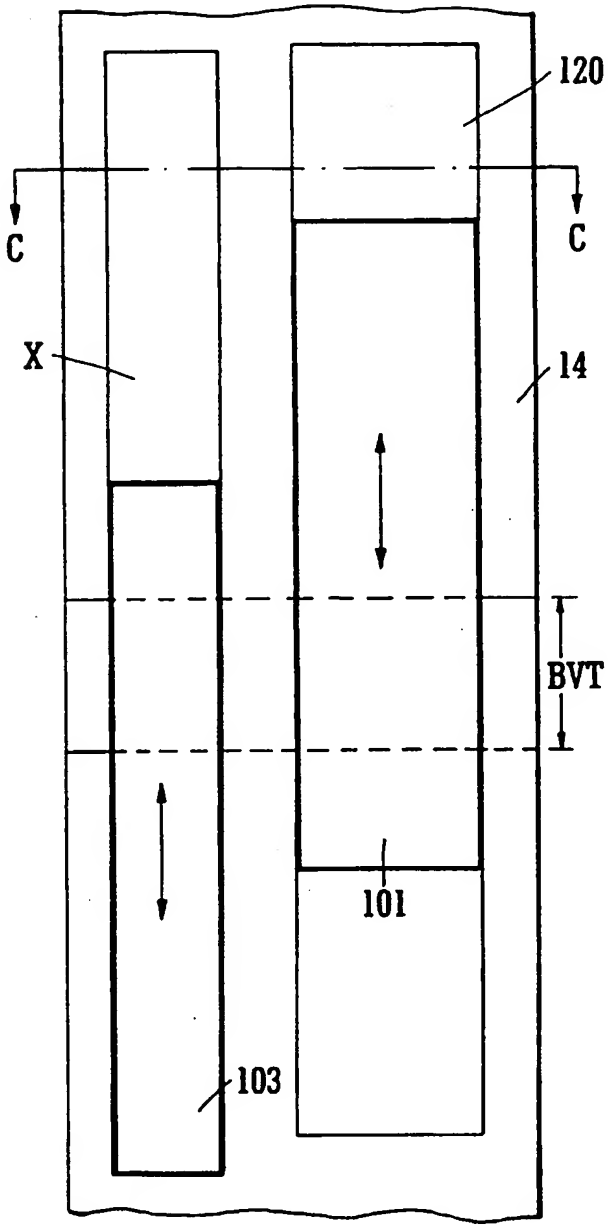

FIG. 8

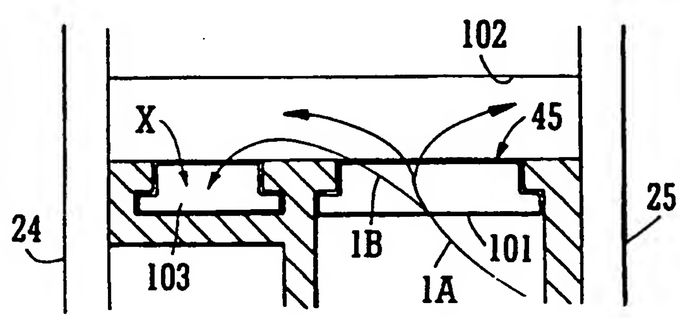

FIG. 9

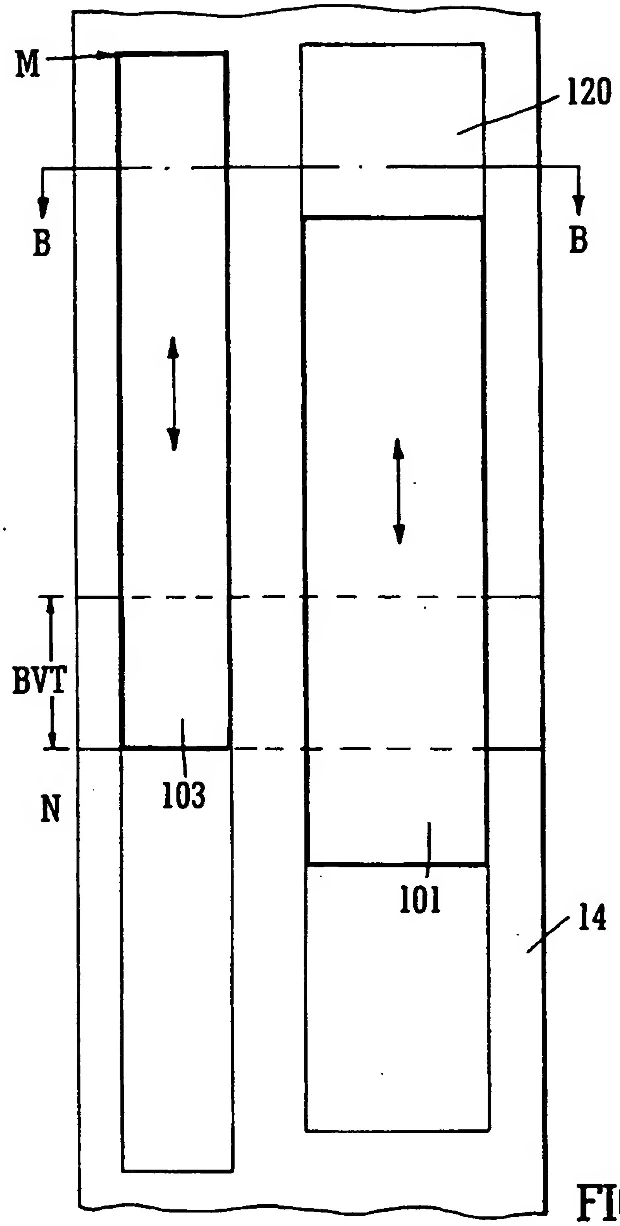

FIG. 6

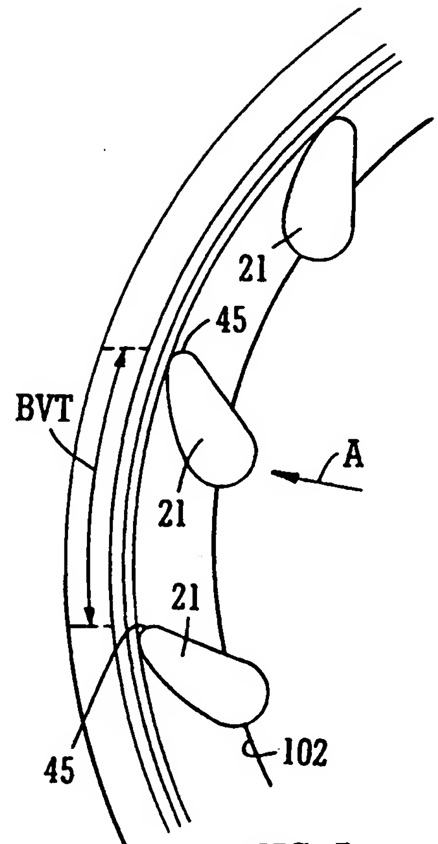

FIG. 5

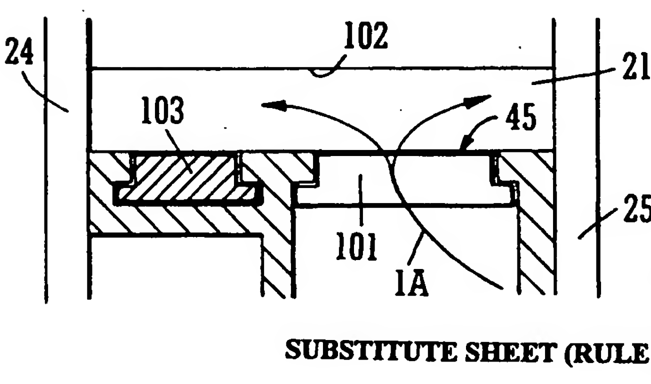

FIG. 7

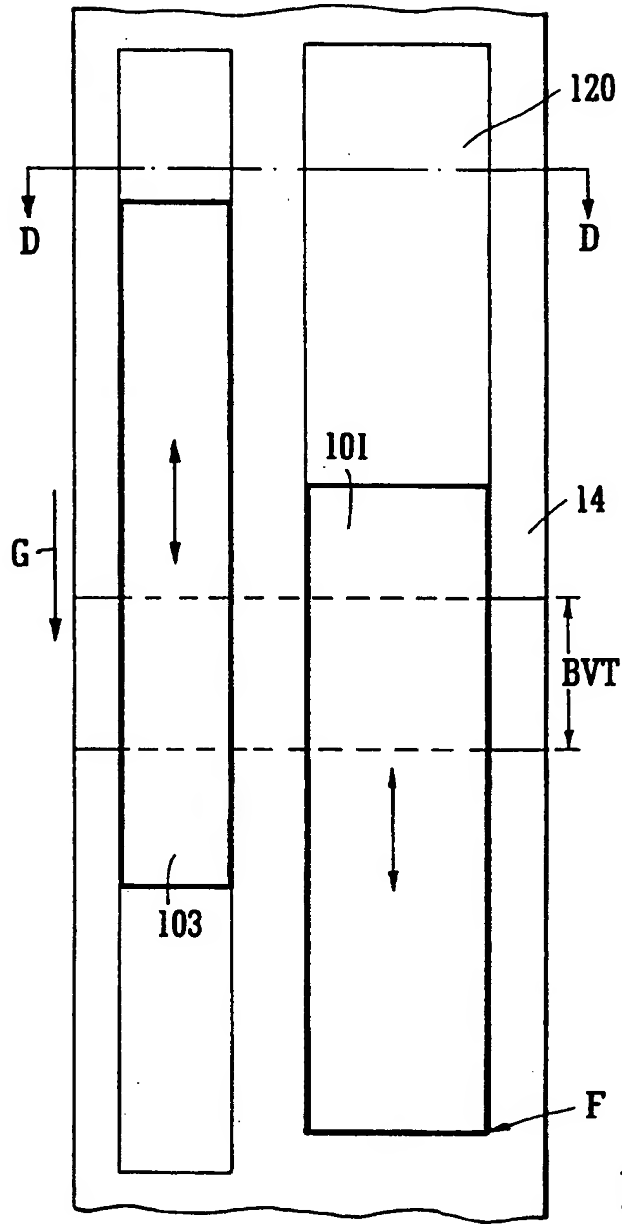

FIG. 10

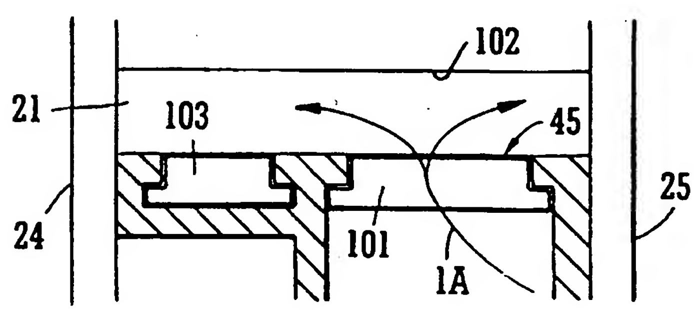

FIG. 11

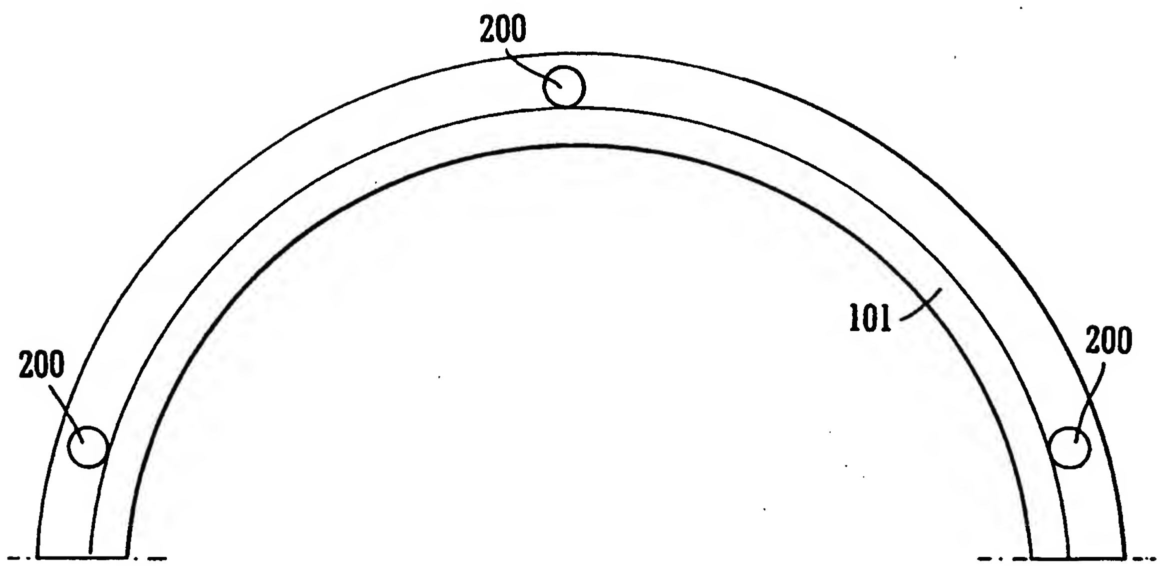

FIG. 12A

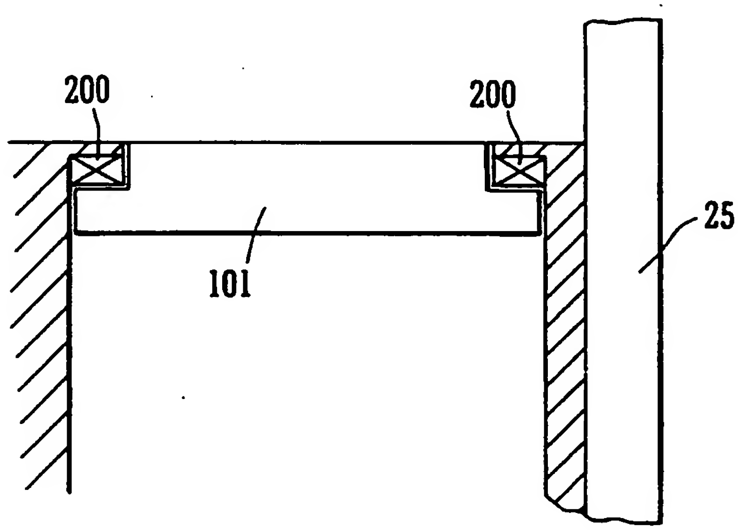

FIG. 12B

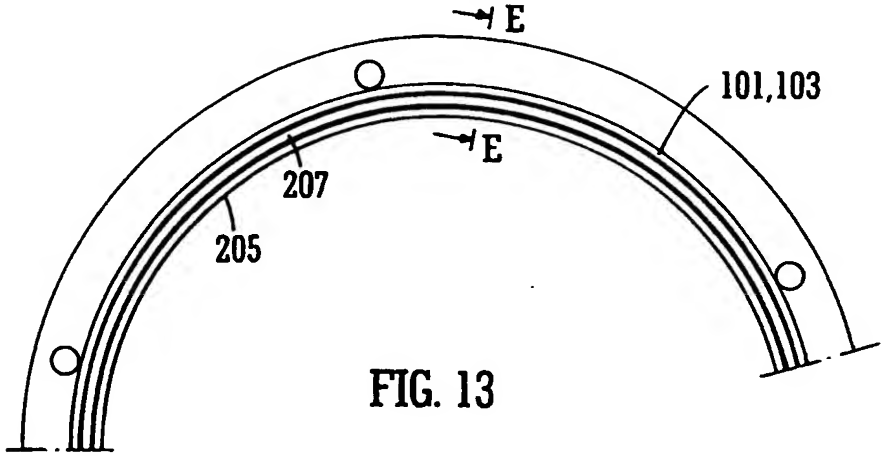

FIG. 13

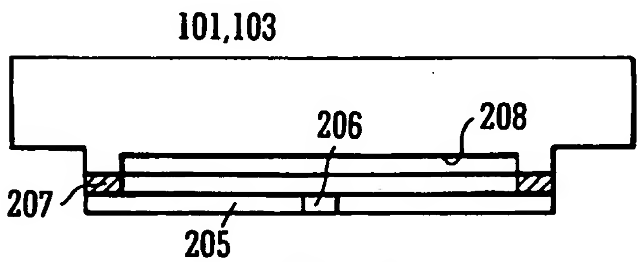

FIG. 14

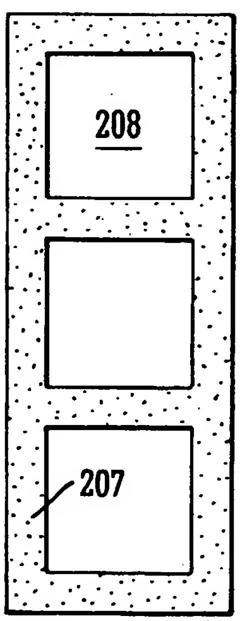

FIG. 15A

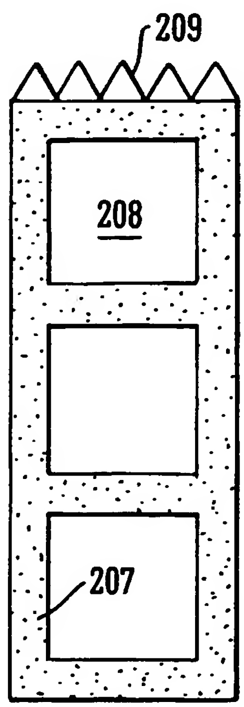

FIG. 15B

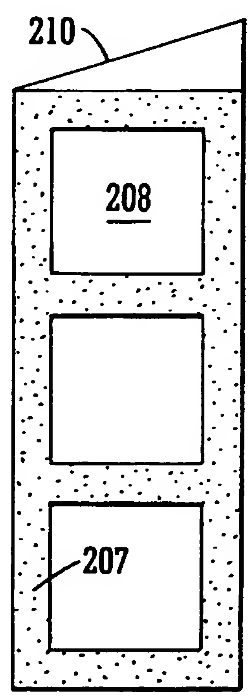

FIG. 15C

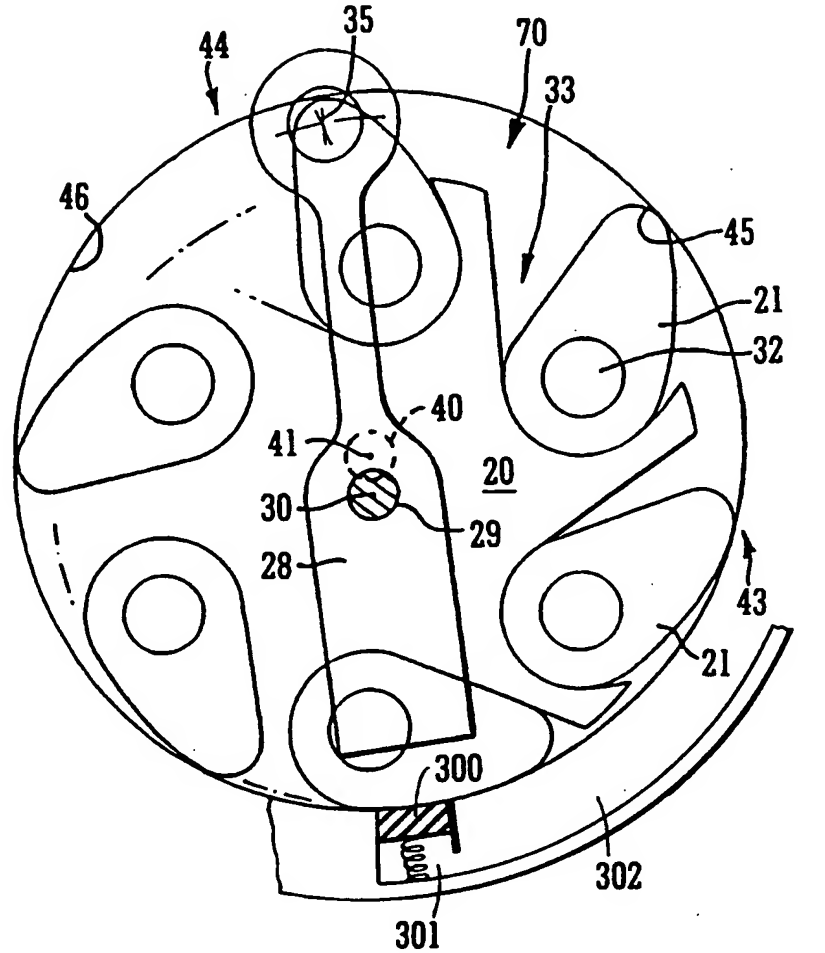

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FIG. 16

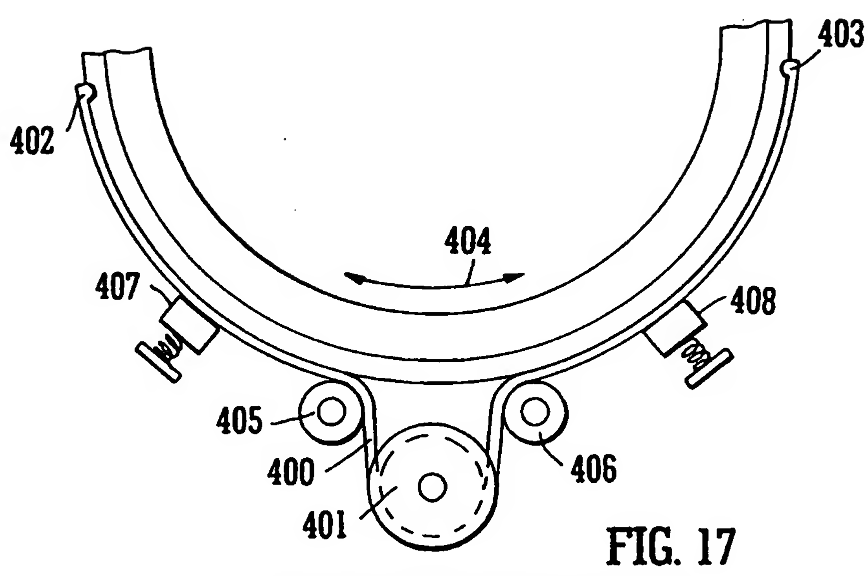

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FIG. 17

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/03465

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F04C29/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F04C F01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 98 57039 A (DRIVER TECHNOLOGY LTD) 17 December 1998 (1998-12-17) cited in the application page 8, line 6 -page 9, line 3; figures 3,11	1-6,13
Y	DE 37 11 519 A (MANNESMANN AG) 27 October 1988 (1988-10-27) column 2, line 22 -column 4, line 14 column 5, line 10 -column 6, line 60; figures	1-6,13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search	Date of mailing of the international search report
21 December 2000	04/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kapoulas, T

1

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/GB 00/03465

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 94 00680 A (FANJA LTD) 6 January 1994 (1994-01-06) page 2, line 27 -page 4, line 35 page 5, line 17 -page 7, line 5; figures 1-4 page 8, line 18 -page 9, line 35; figures 5-8	1
A	US 4 299 097 A (SHANK) 10 November 1981 (1981-11-10) column 4, line 23 -column 5, line 19; figure 5	1,4
A	CH 167 262 A (MASCHINENFABRIK BURCKHARDT) 15 February 1934 (1934-02-15) page 1, line 1 -page 2, left-hand column, line 14; figures	1-5

1

INTERNATIONAL SEARCH REPORT

...ormation on patent family members

Interr ...al Application No
PCT/GB 00/03465

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CH 167262 A	15-02-1934	NONE	

DERWENT-ACC-NO: 2001-244857

DERWENT-WEEK: 200140

TITLE: **Rotary** positive-displacement fluid machine has sliding throttle with slider that permits controlled fluid flow into and from chambers and permits controlled leakage of fluid between adjacent chambers

INVENTOR: **DRIVER,** R W

PATENT-ASSIGNEE: DRIVER TECHNOLOGY LTD[DRIVN]

PRIORITY-DATA: 1999GB-0021459 (September 11, 1999)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
WO 200120167 A1	March 22, 2001	E	026	F04C 029/10
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DESIGNATED-STATES: AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CR CU CZ DE
DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR
LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM
TR TT TZ UA UG US UZ VN YU ZA ZW AT BE CH CY DE DK EA ES FI FR GB GH GM GR IE
IT KE LS LU MC MW MZ NL OA PT SD SE SL SZ TZ UG ZW

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
WO 200120167A1	N/A	2000WO-GB03465	September 11, 2000
AU 200070263A	N/A	2000AU-0070263	September 11, 2000
AU 200070263A	Based on	WO 200120167	N/A

INT-CL (IPC): F04C029/10

ABSTRACTED-PUB-NO: WO 200120167A

BASIC-ABSTRACT:

NOVELTY - A sliding throttle includes a slider that is movable to permit controlled fluid flow into and from the chambers of a casing. The slider also permits controlled leakage of fluid between an adjacent pair of chambers to

allow fluid to expand within the chambers without applying motive force to the rotor, thereby preventing excessive drop in fluid temperature.

DETAILED DESCRIPTION - The rotor is mounted in the casing and rotates about an axis. The rotor has recesses that receive vanes which oscillate as the rotor rotates. The vanes divide the interior of the casing into separate chambers of cyclically varying volume as the rotor rotates.

USE - None given.

ADVANTAGE - Enables operation of sliders to be computer controlled, thereby enabling engine management system to obtain optimum running and maximum advantage from fluid machine.

DESCRIPTION OF DRAWING(S) - The figure shows an engine.

CHOSEN-DRAWING: Dwg.4/17

TITLE-TERMS: ROTATING POSITIVE DISPLACEMENT FLUID MACHINE SLIDE THROTTLE SLIDE
PERMIT CONTROL FLUID FLOW CHAMBER PERMIT CONTROL LEAK FLUID ADJACENT CHAMBER

DERWENT-CLASS: Q56

SECONDARY-ACC-NO:
Non-CPI Secondary Accession Numbers: N2001-174327